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The distribution and cover of plant species on Carnac Island, Western Australia.

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Abstract

The projective foliage cover in 1975 of all 97 plant species present on Carnac Island, a small island near Fremantle, was assigned to one of 6 categories. Although 53 species are naturalized aliens, most have a small distribution and/or low cover on the island. Closed-heath is the major structural vegetation formation. Distribution maps of 9 species characterizing 9 plant communities on Carnac Island are given. Possible ecological bases of these groupings are discussed in terms of exposure to sea spray, soil depth and nesting populations of seabirds. Parts of the vegetation map for the island are different from one drawn up in 1952.

Introduction

Carnac Island is a small low island 8 km west of Fremantle, Western Australia. It has an area of 16 ha and a maximum elevation of 17 m. During 1975-7 70 days were spent on the island chiefly studying the ecology of a bird species. Much time, however, was spent mapping the distribution of the most common and the rarest plant species, as well as compiling a list of the island's flora. This list, together with lists of plant species from adjacent islands, formed the basis of a paper dealing with the biogeography of the floras of the islands near Perth (Abbott 1977).

In this paper distribution maps are presented of 9 of the most conspicuous species and of 16 of the rarest and least conspicuous species, and a complete list of angiosperm species found is provided. The projective foliage cover of all species has been assigned to one of 6 categories. The paper concludes with a brief discussion of the plant ecology of Carnac Island relative to soil types, seaspray, seabirds and other factors.

Previous botanical studies on the island are relatively extensive. Preiss visited the island on 8 November 1839 but collected only 5 species (Lehmann 1838-1841), of which 4 have never been recollected on the island (see later). The ornithologist Gilbert was there during 1839 and recorded 'a species of *Malva*', probably *Lavatera plebeia* (see Whittell 1942). There is then a long interval until McArthur collected 34 species on 21 January 1952 (McArthur 1957). In the late 1950s G. M. Storr and M. E. Gillham collected on the island. Storr's list was used in the study referred to above (Abbott 1977) and Gillham made use of some of her observations in developing her theory concerning the role of seabirds in vegetational cycles on islands (Gillham 1961). Lindgren visited the island for one day each month during 1966-7 and has provided a useful list of the phenology of all plant species (Lindgren 1973, p. 163).

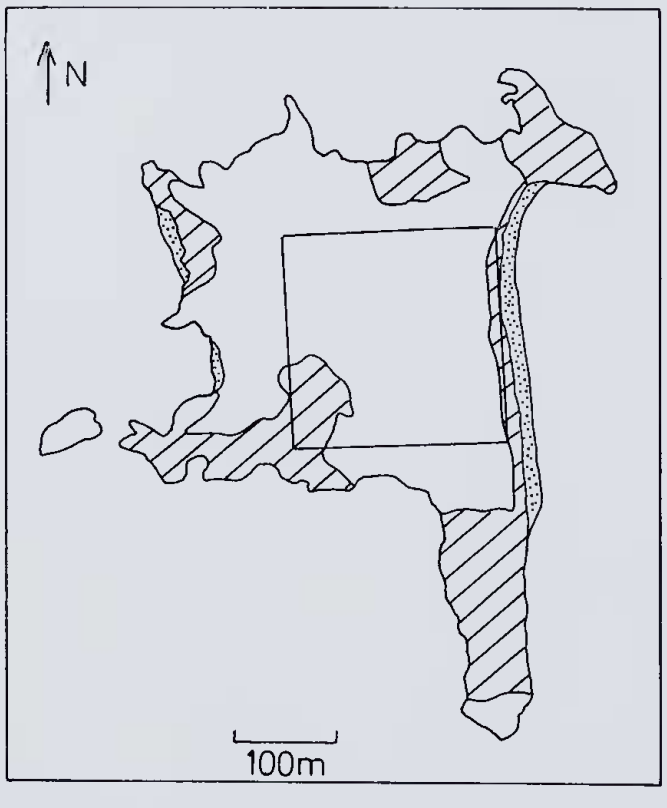

Figure 1.—Carnac Island, showing sand beaches (dots), Silver gull rookeries (diagonal lines) and 4 ha area in which quadrats were distributed at random (square).

Table 1

List of plant species found on Carnac Island in 1975.

* indicates naturalized alien species. Cover classes represent the following areas: 1, < 10 m^2; 2, 10–100 m^2; 3, 10^2–10^3 m^2; 4, 10^3–10^4 m^2; 5, 10^4–10^5 m^2; 6, > 10^5 m^2.

Species	Family	Cover class
Acacia cyclops A. Cunn. ex G. Don	Mimosaceae	3
A. rostellifera Benth.	Mimosaceae	5
Acanthocarpus preissii Lehm.	Liliaceae	5
**Anagallis arvensis* L.	Primulaceae	4
Apium prostratum Vent.	Apiaceae	4
**Arctotheca calendula* (L.) M. Levyns	Asteraceae	2
**Atriplex patula* L.	Chenopodiaceae	1
**Avena barbata* Brot.	Poaceae	3
**Bellardia trixago* (L.) All.	Scrophulariaceae	2
**Brassica tournefortii* Gouan	Brassicaceae	2
Bromus arenarius Labill.	Poaceae	1
**B. diandrus* Roth	Poaceae	3
Calandrinia calyptrata Hook.f.	Portulacaceae	2
Calocephalus brownii (Cass.) F. Muell.	Asteraceae	1
**Carduus pycnocephalus* L.	Asteraceae	2
Carex preissii Nees	Cyperaceae	1
Carpobrotus virescens (Haw.) Schwantes	Aizoaceae	4
**Catapodium rigidum* (L.) C.E. Hubb.	Poaceae	1
**Centaurea melitensis* L.	Asteraceae	1
**Cerastium glomeratum* Thuill.	Caryophyllaceae	1
**Chenopodium murale* L.	Chenopodiaceae	2
Clematis microphylla DC.	Ranunculaceae	4
Conospermum integerrimum Endl.	Polygalaceae	1
Cotula coronopifolia L.	Asteraceae	1
Crassula colorata (Nees) Ostenf.	Crassulaceae	2
C. glomerata L.	Crassulaceae	1
C. pedicellosa (F. Muell.) Ostenf.	Crassulaceae	1
**Crepis foetida* L.	Asteraceae	1
Daucus glochidiatus (Labill.) Fisch. et al.	Apiaceae	1
**Dischisma arenarium* E. Mey.	Scrophulariaceae	1
**Ehrharta brevifolia* Schrad.	Poaceae	1
E. longiflora Sm.	Poaceae	3
Enchylaena tomentosa R.Br.	Chenopodiaceae	4
**Erodium cicutarium* (L.) L'Herit. ex Ait.	Geraniaceae	2
**Euphorbia peplus* L.	Euphorbiaceae	3
Frankenia pauciflora DC.	Frankeniaceae	5
**Galium murale* (L.) All.	Rubiaceae	3
**Gasoul crystallinum* (L.) Rothmaler	Aizoaceae	1
**Geranium molle* L.	Geraniaceae	3
**Hordeum leporinum* Link	Poaceae	2
Hydrocotyle diantha DC.	Apiaceae	1
Hymenolobus procumbens (L.) Nutt.	Brassicaceae	1
**Hypochoeris glabra* L.	Asteraceae	2
**Lactuca serriola* L.	Asteraceae	1
**Lagurus ovatus* L.	Poaceae	2
**Lavatera arborea* L.	Malvaceae	3
L. plebeia Sims	Malvaceae	2
Lepidium foliosum Desv.	Brassicaceae	4
Lepidosperma gladiatum Labill.	Cyperaceae	3
**Lolium rigidum* var. *rottbollioides* Boiss.	Poaceae	3
**Malva parviflora* L.	Malvaceae	2
**Medicago polymorpha* L.	Fabaceae	2
**Melilotus indica* (L.) All.	Fabaceae	3
Nitraria schoberi L.	Zygophyllaceae	4
Olearia axillaris (DC.) F. Muell.	Asteraceae	5
**Parapholis incurva* (L.) C.E. Hubb.	Poaceae	1
Parietaria debilis Forst. f.	Urticaceae	2
Pelargonium capitatum (L.) Ait.	Geraniaceae	3
**Phoenix canariensis* Hort. ex Chabaud	Arecaceae	1
**Poa annua* L.	Poaceae	2
P. poiformis (Labill.) Druce (formerly called *P. australis* R.Br. at W.A. Herbarium)	Poaceae	2
Podosperma angustifolium Labill.	Asteraceae	2
**Polycarpon tetraphyllum* Loef.	Caryophyllaceae	1
**Raphanus raphanistrum* L.	Brassicaceae	1
**Rapistrum rugosum* (L.) All.	Brassicaceae	1
Rhagodia baccata (Labill.) Moq.	Chenopodiaceae	5
**Rumex pulcher* L.	Polygonaceae	1
**Sagina apetala* Ard.	Caryophyllaceae	1
Sarcocornia quinqueflora (Bunge ex Ung.-Stern.) A.J. Scott	Chenopodiaceae	1
Salsola kali L.	Chenopodiaceae	1
Scaevola crassifolia Labill.	Goodeniaceae	5
Scirpus autarcticus Labill.	Cyperaceae	1
S. nodosus L.	Cyperaceae	2
Senecio lautus Forst.f. ex Willd.	Asteraceae	3
**Silene nocturna* L.	Caryophyllaceae	2
**Sisymbrium irio* L.	Brassicaceae	1
**S. orientale* L.	Brassicaceae	2
**Solanum nigrum* L.	Solanaceae	1
S. symonii Eichler	Solanaceae	1
**Sonchus megalocarpus* (Hook.f.) J.M. Black	Asteraceae	1
**S. oleraceus* L.	Asteraceae	2
Spinifex longifolius R.Br.	Poaceae	3
Spyridium globulosum (Labill.) Benth.	Rhamnaceae	2
**Stellaria media* (L.) Vill.	Caryophyllaceae	3
Stipa flavescens Labill. (formerly called *S. variabilis* D.K. Hughes at W.A. Herbarium)	Poaceae	2
Tetragonia amplexicoma (Miq.) Hook.f.	Aizoaceae	2
T. decumbens Mill.	Aizoaceae	3
Threlkeldia diffusa R.Br.	Chenopodiaceae	4
**Trachyandra divaricata* (Jacq.) Kunth.	Liliaceae	3
**Trifolium campestre* Schreb. in Sturm	Fabaceae	2
**T. scabrum* L.	Fabaceae	1
**T. tomentosum* L.	Fabaceae	1
Triglochin trichophora Nees	Juncaginaceae	1
**Urospermum picroides* (L.) F.W. Schmidt	Asteraceae	2
**Urtica urens* L.	Urticaceae	2
**Vulpia myuros* (L.) Gmel.	Poaceae	1
**Zantedeschia aethiopica* (L.) Spreng.	Araceae	1

Methods

Carnac Island was visited 10 times over 3 years, spanning all seasons. Each visit was of one week's duration. Dates of these visits are given by Abbott (1978). Specimens were collected of all species seen and were determined by the staff of the Western Australian Herbarium and the Botany Department, University of Western Australia. Only fragments of very rare species were collected, so as not to cause their depletion or extinction. The distribution of various species was marked on maps made from a large scale aerial photograph of the island. The projective foliage cover of each plant species was then estimated and assigned to one of six categories (see Table 1). The maximum cover possible is 1.6 x 10^5 m^2, the area of the island. High cover values need not necessarily indicate great abundance; a projective foliage cover value of 150 m^2, for example, could represent either species with many individual plants (e.g. weeds) or those medium-sized shrubs such as *Acacia rostellifera* with fewer individual plants.

In January 1975 a 4 ha site (Fig. 1) was sampled with 50 1 m^2 randomly placed quadrats. This permitted a more detailed analysis of the most widespread plant community on the island.

Results

Ninety seven plant species were recorded (Table 1), of which 53 are aliens (indicated by an asterisk in Table 1). Table 2 shows the number of plant species in each cover class. The cover classes have been defined on a $\log_{10}$ scale, but this is approximate only because class 1 is defined as < 10 m^2 and not 1 - 10 m^2. Despite this, the frequency (in the statistical sense) of the projective foliage cover of plant species on Carnac Island shows a reasonable approximation to the commonly found lognormal distribution (Preston 1962) in which there are more species with small cover than ones with large cover. Only one alien species has a cover value greater than 3, whereas 13 native species are category 3 or higher. In the first 3 classes of cover there are more alien

Table 2

Number of plant species in each class of projective foliage cover.

	Cover class					
	1	2	3	4	5	6
All species	38	28	17	8	6	0
Aliens	23	18	11	1	0	0
Natives	15	10	6	7	6	0

Table 3

Frequency and median and mean projective foliage cover of the seven most frequent plant species on a 4 ha site on Carnac Island in January 1975.

Species	% Frequency	% Cover		
		Mean	Median	Range
Acacia rostellifera	66	35	25	2–100
Rhagodia baccata	64	37	20	2–100
Olearia axillaris	40	20	15	5–60
Threlkeldia diffusa	38	22	11	2–60
Acanthocarpus preissii	38	28	15	3–100
Clematis microphylla	26	15	15	5–25
Carpobrotus virescens	20	18	9	1–100

Based on fifty 1 m² quadrats randomly distributed in a 4 ha site (Fig. 1). Only species with a frequency of 20% or more are included.

species represented (52) than native ones (31). There is therefore a significant association between plant origin (i.e. native vs alien) and cover ($\chi^2_1 = 12$, $P < 0.001$).

These quantitative data may allow future workers to monitor whether alien species on Carnac Island increase in projective foliage cover at the expense of native species.

Quadrat analysis

Because sampling was in summer only the frequency (i.e. per cent occurrence in 50 1 m² quadrats) and projective foliage cover (in the same number of quadrats) of perennial species are given (Table 3), Seven species had a frequency of 20% or higher. In almost every case the median percentage cover is less than the mean percentage cover, indicating that cover valus are not normally distributed but instead are positively skewed. Most quadrats have a low percentage projective foliage cover for each plant species. The most frequent perennial species tend to have the highest median projective foliage covers (Table 3).

Maps of species distribution

Six of the 7 most abundant species are mapped: *Acacia rostellifera* and *A. cyclops* (Fig. 2), *Rhagodia baccata* and *Frankenia pauciflora* (Fig. 3), *Scaevola crassifolia* (Fig. 4), *Olearia axillaris* (Fig. 5) and *Nitraria schoberi*, *Tetragonia decumbens* and *T. amplexicoma* (Fig. 4). Several locally rare species or easily overlooked species are mapped in Figure 6; this is to aid future workers in relocating these species.

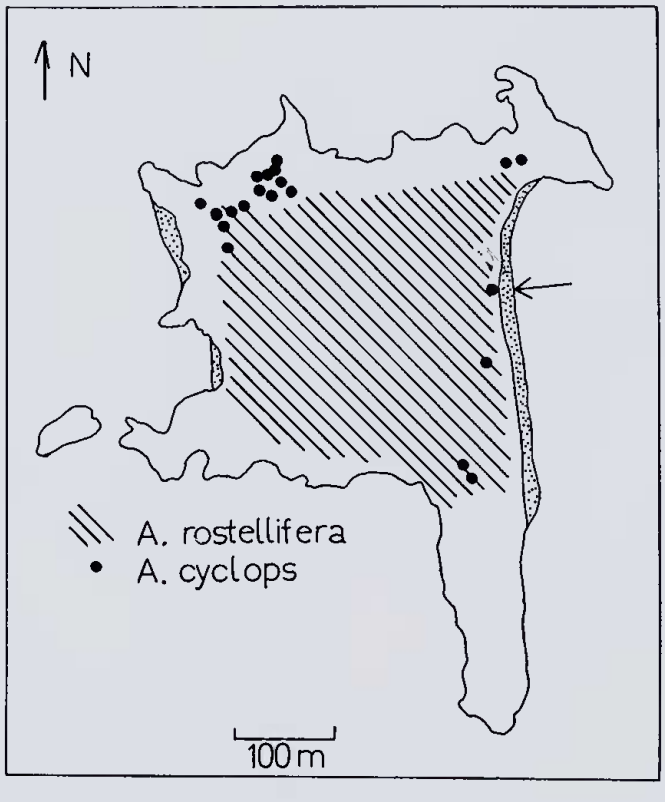

Figure 2.—Distribution of *Acacia rostellifera* and *A. cyclops* on Carnac Island. The use of black circles for *A. cyclops* is meant to convey the patchiness of its distribution; they do not necessarily represent single individuals. The arrow indicates a tree that was killed by exceptionally high tides during winter 1975.

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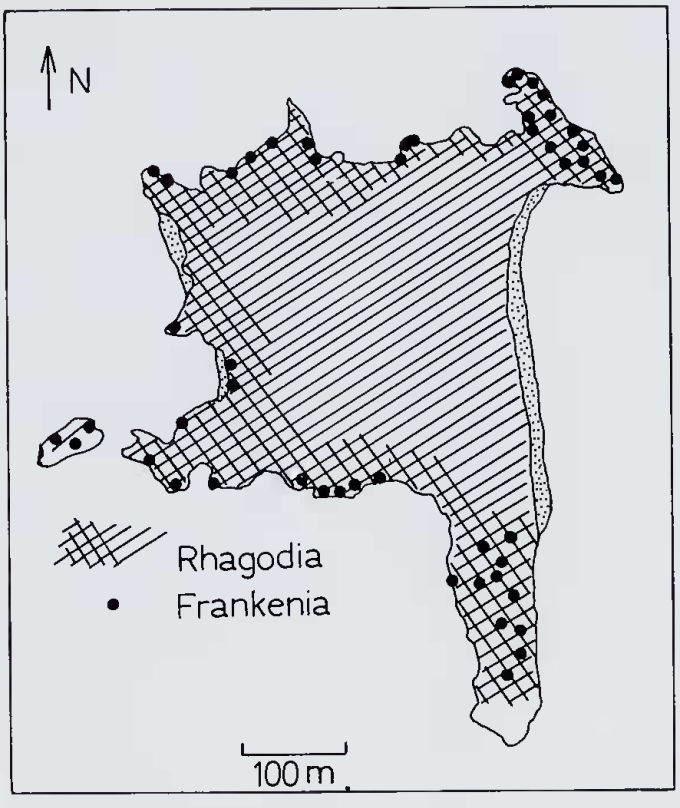

Figure 3.—Distribution of *Rhagodia baccata* and *Frankenia pauciflora* on Carnac Island. Cross-hatching indicates places where *Rhagodia* is particularly common. Use of solid circles as in Figure 2.

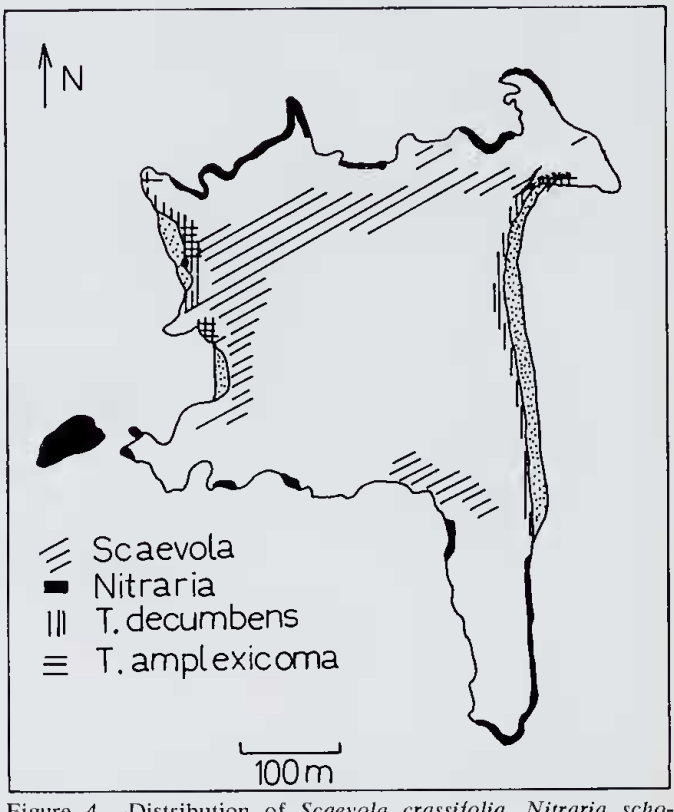

Figure 4.—Distribution of *Scaevola crassifolia, Nitraria schoberi, Tetragonia decumbens* and *T. amplexicoma* on Carnac Island.

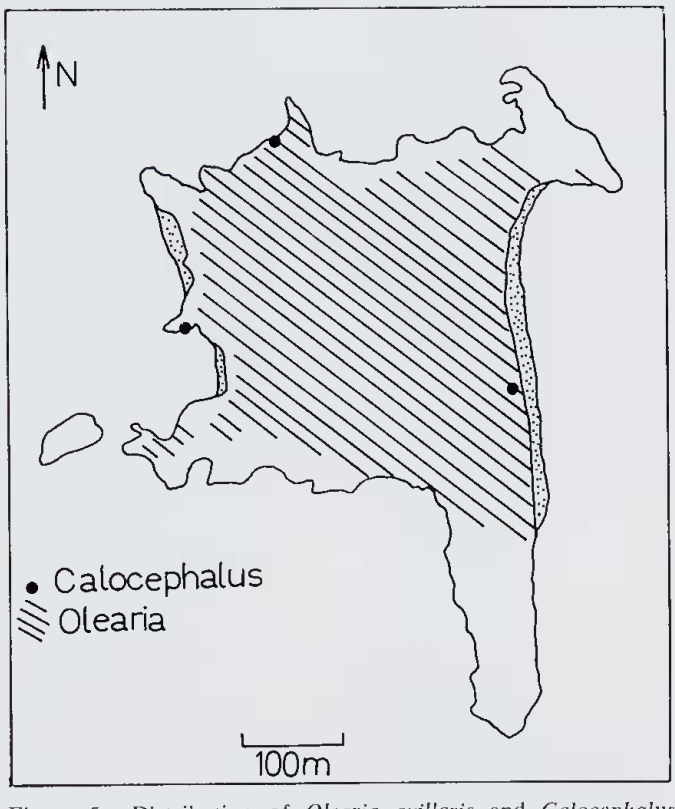

Figure 5.—Distribution of *Olearia axillaris* and *Calocephalus brownii* on Carnac Island. Use of solid circles as in Figure 2.

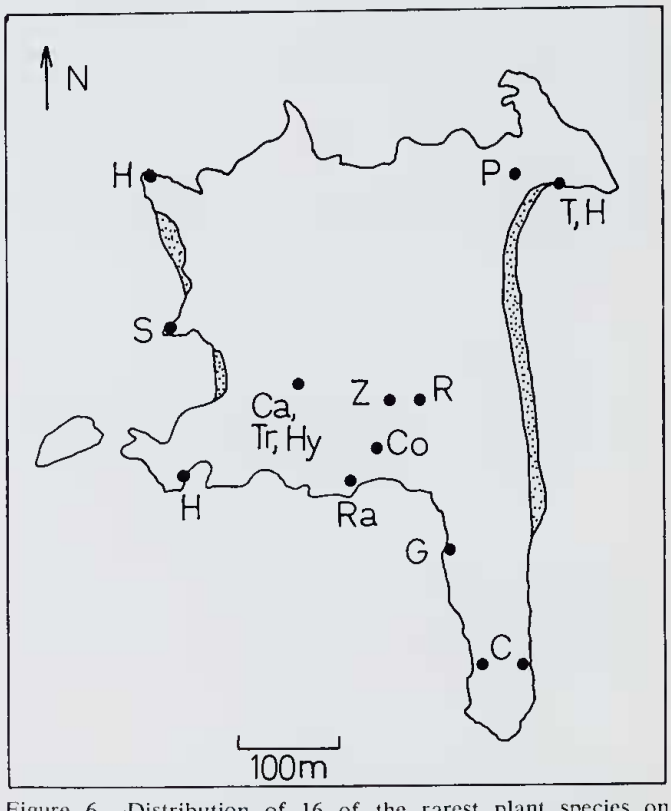

Figure 6.—Distribution of 16 of the rarest plant species on Carnac Island. *Ca—Carex preissii; C—Cotula coronopifolia; Co—Comesperma integerrimum; G—*Gasoul crystallinum; H—Hymenolobus procumbens; Hy—Hydrocotyle diantha; P—*Phoenix canariensis; R—*Rumex pulcher; Ra—*Raphanus raphanistrum* and **Rapistrum rugosum; S—Sarcocornia quinqueflora;* T—*Triglochin trichophora;* Tr—**Trifolium campestre, *T. scabrum* and **T. tomentosum; Z—*Zantedeschia aethiopica.*

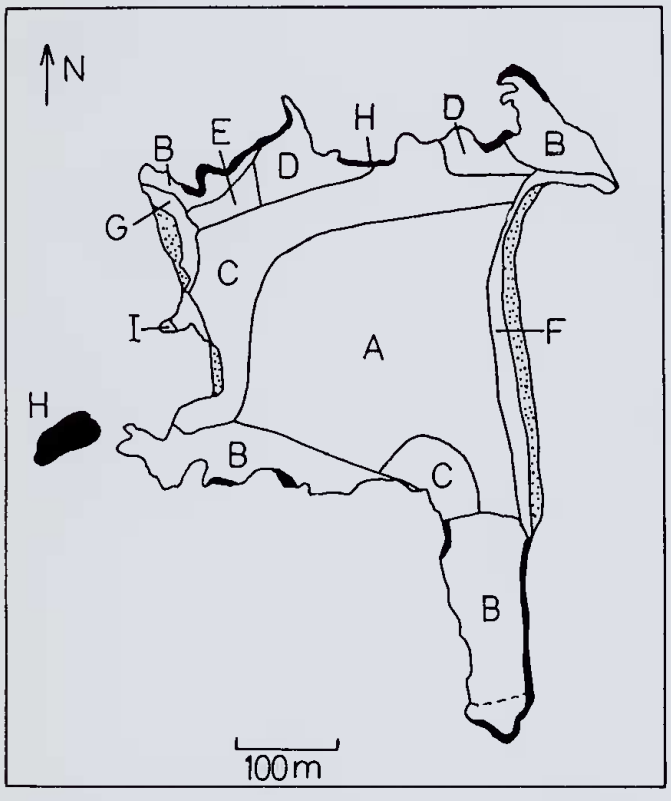

Figure 7.—Vegetation map (1975) of Carnac Island. Plant communities are designated as follows: A—*Acacia rostellifera-Rhagodia baccata-Olearia axillaris* closed-heath; B—*Rhagodia-Frankenia pauciflora* closed-heath C—*Scaevola crassifolia-Rhagodia-Olearia* closed-heath; D—*Rhagodia-Olearia* closed-heath; E—*Acacia cyclops-Rhagodia* closed-heath; F—*Tetragonia decumbens* closed-herbland; G—*Tetragonia-Rhagodia* closed-heath; H—*Nitraria schoberi* closed-heath; I—*Sarcocornia quinqueflora* open-herbland.

Vegetation map of Carnac Island

When Figures 2-5 are integrated, 9 plant communities can be recognized (Fig. 7). The most extensive is closed-heath (Specht 1970) comprising mainly *Acacia rostellifera, Rhagodia baccata* and *Olearia axillaris* (designated A in Fig. 7). This occupies most of the centre and most sheltered part of the island. Comparison of Figures 1 and 7 shows that the 4 ha site sampled with quadrats covered most of this community (see also Table 3). As prevailing winds come from the west or south-west, the height of *Acacia rostellifera,* the tallest member of this community, increases from 1 m to 3-4 m from west to east. Open spaces in this community are occupied most commonly by **Bromus diandrus, *Avena barbata, *Brassica tournefortii, *Ehrharta longiflora* and **Sonchus oleraceus.* (The asterisks indicate species that are naturalized aliens). Prior to disturbance by man on the island, it is suspected that *Acanthocarpus preissii* was probably the dominant ground cover in this community.

The next most extensive community is a closed-heath (B in Fig. 7) dominated by *Rhagodia baccata* and *Frankenia pauciflora.* The *Rhagodia* is between 0.5 and 1 m in height, and the *Frankenia* rarely exceeds 0.5 m. This community is restricted to areas on the edge of the island where the aeolianite has only a shallow depth of soil over it.

The third most extensive community consists predominantly of *Scaevola crassifolia, Rhagodia baccata* and *Olearia axillaris* closed-heath (C, Fig. 7). Height of the tallest member, *Olearia,* rarely exceeds 1 m. Community D is a depauperate version of C, lacking *Scaevola crassifolia.* Community E consists of a closed-heath of *Acacia cyclops* and *Rhagodia baccata;* the height of the *Acacia* just exceeds 2 m. Communities F and G occur on deep sands on the periphery of the island. F is a closed-herbland of *Tetragonia decumbens,* and G a closed-heath of *T. decumbens* with *Rhagodia baccata.* Community H is a monospecific closed-heath found on cliffs and talus slopes around much of the island and consists of *Nitraria schoberi.* The smallest recognizable community on the island, I, consists of *Sarcocornia quinqueflora* open-herbland on the mid-western point.

This vegetation map may be compared with one produced earlier (McArthur 1957). Seven communities were then recognized (Fig. 8): A, *Acacia rostellifera-Olearia axillaris* scrub; B, *Alearia-Scaevola crassifolia* low scrub; C, *Rhagodia baccata-Frankenia pauciflora* low scrub; D, *Scaevola-Calocephalus brownii* low scrub; E, *Rhagodia* low scrub; F, *Carpobrotus virescens-Tetragonia* spp.-*Suaeda maritima* (sic, apparently an error for *Threlkeldia diffusa),* and G, *Nitraria schoberi.* Some of the more obvious differences between the two maps include the following. *Rhagodia baccata* was not seen to be a codominant in McArthur's communities A and B (Fig. 8) whereas Table 3 and Figure

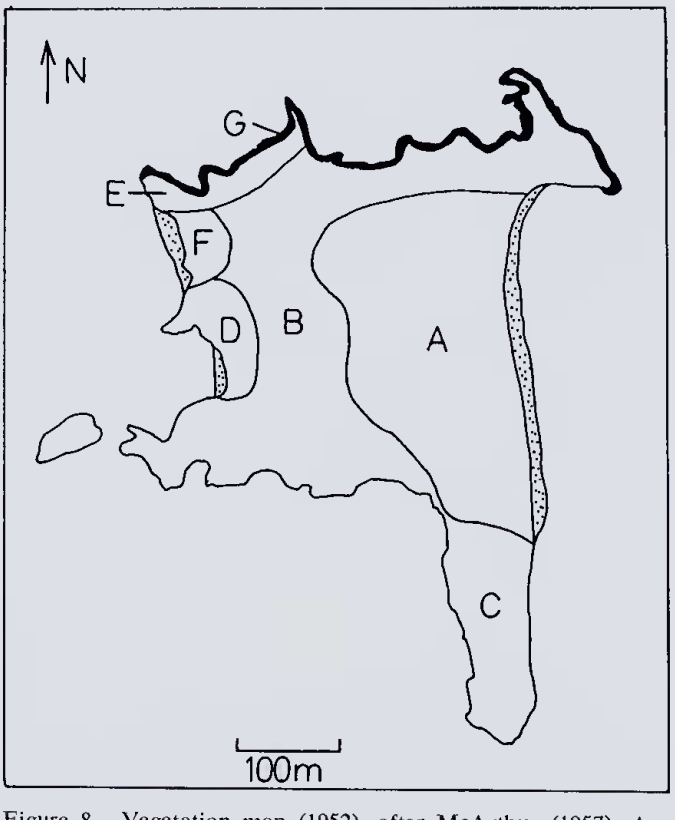

Figure 8.—Vegetation map (1952), after McArthur (1957). A—*Acacia rostellifera-Olearia axillaris* scrub; B—*Olearia-Scaevola crassifolia* low scrub; C—*Frankenia pauciflora-Rhagodia* low scrub; D—*Scaevola-Calocephalus brownii* low scrub; E—*Rhagodia* low scrub; F—*Carpobrotus virescens-Tetragonia* spp.—*Suaeda maritima* (sic) mat; G—*Nitraria schoberi* low scrub.

3 show it to be widespread and with a high projective foliage cover. Second, McArthur indicated that the community on the north-east peninsula was the same as his community B, but this is not so now. McArthur's community D (Fig. 8) gives *Calocephalus brownii* the status of a codominant species, whereas today it is quite rare on Carnac Island (Fig. 5) and makes no contribution to the physiognomy of the vegetation. McArthur (1952) stated that this species extended about 50 m back from the coast. *Nitraria schoberi* was stated by McArthur to be present only on the northern side of the island, but its distribution now is wider. Other differences are evident from carefully comparing Figures 7 and 8.

There are two possibilities to be considered in explaining these changes in vegetation over 25 years. First, changes in weather patterns, the density of grazing rabbits, occurrence of fires or of human use of the island may be responsible. Alternatively, differences between Figures 7 and 8 may be more apparent than real because McArthur was only able to spend one day (in mid-summer) on the island. I prefer to adopt the conservative conclusion that Figure 8 was based on insufficient reconnaissance to form a reliable baseline. This of course does not rule out that a real change in vegetation did not occur.

Plant ecology of Carnac Island

Without appropriate experimentation it is difficult to sort out the effect of differences in exposure to seaspray, the type and depth of soil, and the concentration of seabird guano in determining the distribution and cover of the plant species on Carnac Island.

Because McArthur visited the island in summer, when none of the surface-nesting species of seabirds breed, he not surprisingly makes no mention of the importance that seabirds have on the plant ecology. Instead, soil and substrate type, as well as wind and hence seaspray, were emphasized as factors controlling the vegetational and plant diversity. As is clear from Figure 1, nesting areas of Silver gulls *(Larus novaehollandiae)* covered, in 1975, at least half of the island. Gull rookeries alter the vegetation structure to a certain extent. Thus parts of communities A, B, and C (Fig. 7) have been converted from closed-heath to open-heath, mainly through the deposition of guano (Gillham 1961). Seventeen plant species are either found only in the gull rookeries or are most common in them: **Arctotheca calendula, Bromus arenarius, Calandrinia calyptrata, *Chenopodium murale, *Erodium cicutarium, *Lavatera aborea, L. plebeia, Lepidium foliosum, *Lolium rigidum. *Malva parviflora, *Medicago polymorpha, Parietaria debilis, *Poa annua, Senecio lautus, *Sisymbrium orientale, *Stellaria media* and **Urtica urens.*

Certain species are restricted to, or are most common near, the edge of the island. This is the part of the island most prone to receive heavy deposition of salt spray, but it is also where aeolianite mainly outcrops, so that soils (pH 7.1) there are the shallowest on the island. These sites are favoured by nesting Silver gulls. Such plant species are: *Apium prostratum, Bromus arenarius, Calandrinia calyptrata, Calocephalus brownii, Cotula coronopifolia, Frankenia pauciflora, Lavatera plebeia, Lepidium foliosum, *Lolium rigidum, *Malva parviflora, Nitraria schoberi* (more common on talus slopes), **Poa annua, *Sagina apetala, Sarcocornia quinqueflora, Senecio lautus, *Sisymbrium orientale, *Stellaria media* and **Urtica urens.*

Species apparently restricted to, or best developed in, deep sandy soil (pH 7.4) occur in the central-eastern sector of the island. Such species include both *Acacia* species, *Acanthocarpus preissii, *Anagallis arvensis, *Avena barbata, *Bellardia trixago, *Brassica tournefortii, *Bromus diandrus, *Carduus pycnocephalus, *Centaurea melitensis, * Cerastium glomeratum, Clematis microphylla, *Crepis foetida, Daucus glochidiatus,*Dischisma arenarium, *Ehrharta longiflora, *Euphorbia peplus, *Galium murale, *Geranium molle, Lepidosperma gladiatum, *Melilotus indica, Olearia axillaris, Parietaria debilis, Pelargonium capitatum, Podosperma angustifolium, Salsola kali, Scaevola crassifolia, Scirpus antarcticus, S. nodosus, *Silene nocturna,* both **Sonchus* species, *Spinifex longifolius, Tetragonia decumbens, *Trachyandra divaricata* and **Urospermum picroides.* Deepest sands tend to be best developed in the eastern half of the island, which is the most sheltered from seaspray, so these species may be responding to absence of guano and salt spray as well as soil depth. Some species could be excluded from aeolianite pavement through competition.

The remainder of the plant species are widespread over the island or require no special comment.

As is usual with most island floras, there are species which should be expected on, but are missing from, Carnac Island. Judging from my experience on all the islands near Perth (Abbott 1977), and in particular the northern end of Garden Island, only 3 km south of Carnac Island, I include the following plant species in this category: *Acrotriche cordata* (Labill.) R.Br., *Alyxia buxifolia* R.Br., *Cassytha* species, *Conostylis candicans* Endl., *Dichondra repens* Forst. & Forst. f., *Eremophila glabra* (R.Br.) Ostenf., *Exocarpos sparteus* R.Br., *Hardenbergia comptoniana* (Andr.) Benth., *Leucopogon parviflorus* (Andr.) Lindl., *Myoporum adscendens* R.Br., *Pittosporum phillyraeoides* DC. and *Sporobolus virginicus* (L.) Kunth. Doubtless many of these species were present when the bridge between Carnac and Garden Islands became submerged about 5000 yr BP (deduced from RAN chart 117 and graph in Thom and Chappell 1975), but have since become extinct on Carnac Island. *Alyxia buxifolia* (in the above list), as well as *Stipa elegantissima* Labill., *Phyllanthus calycinus* Labill. and *Zygophyllum australasicum* Miq. were collected on Carnac Island in November 1839 by Dr L. Preiss (Lehmann 1838-1841), but they are not now present on the island.

Factors that may have played a part in causing extinctions include the extinction of the Tammar wallaby *Macropus eugenii* probably soon after Carnac became isolated (A. R. Main, 1976 pers. comm.); increased degree of exposure to salt spray; presumed increase in abundance of nesting Silver gulls, especially since the founding of Perth in 1829; the introduction of rabbits in the 1820s (Seddon 1972, Abbott 1978), and attempts to farm sheep on the island (there is a well in the central-eastern sector which was probably cleared at some stage, but no details are available). These herbivores would have altered the vegetation and flora of the island by preferentially

cating palatable plant species, thereby allowing the unpalatable ones to become more common. Some of the early effects of man on the ecology of Carnac Island are briefly discussed by Seddon (1972, p. 215).

The impact of rabbits on the ecology of Carnac Island was evidenced when carrots, poisoned with the fluoroacetate 1080, were distributed by hand over the island on 13 May 1969. The next day 60 carcases were found and all subsequent inspections have shown that rabbits are now absent (A. J. Oliver, 1978 pers. comm.; pers. obs.). Comparison of colour aerial photographs (scale 1 : 4800) taken on 21 April 1969 and 14 February 1972 clearly show the marked recovery of the island's vegetation. At the second date there was more straw (dead grass) in community A, replacing much bare sand evident in the earlier photograph. The communities dominated by low-growing plant species (B, F and G in Fig. 7) show an increase in ground cover. Studies elsewhere have shown that grazing by rabbits tends to cause the less palatable plant species to increase in cover and to lead to a decline in dry matter production (Myers and Poole 1963), as well as increasing plant species diversity if the tall-growing species are preferentially browsed (Gillham 1955).

The role of grazing by Tammars especially requires further study if their influence on the vegetation of the island is to be evaluated properly. The vegetation on the western coast of Garden Island is similar to that on Carnac Island, and Tammars have the lowest density there of all habitats on Garden Island (Kelsall 1965). Tammars find *Rhagodia baccata* palatable on Garden Island, so their absence from Carnac Island may help explain the abundance of this plant species on Carnac. On West Wallabi Island in the Houtman Abrolhos, *Alyxia buxifolia* and *Nitraria schoberi* amongst other plant species are over-browsed by Tammars (Kelsall 1965). Several species, including *Acacia rostellifera, Eremophila glabra, Myoporum adscendens, Nitraria schoberi, Olearia axillaris, Scaevola crassifolia, Sporobolus virginicus* and *Spyridium globulosum,* on Rottnest Island are preferentially grazed by the Quokka *Setonix brachyurus* (Storr 1957). Plant species resistant to this grazing dominate the vegetation, although on Rottnest other factors such as fire history are important. The sedge *Carex preissii,* although rare on Carnac Island (Fig. 6), was of vigorous stature and was found fruiting. On Rottnest and Garden Islands the wallabies find them very palatable and consequently the sedge is continually browsed. I have not found *Carex preissii* in fruit on these two islands.

In summary, little that is definitive can be written about the causes of the distribution and cover of individual plant species on Carnac Island until appropriate experimental studies are made. These will involve the role of seabirds, grazing wallabies and rabbits, seaspray, and competition between plant species, considered together.

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